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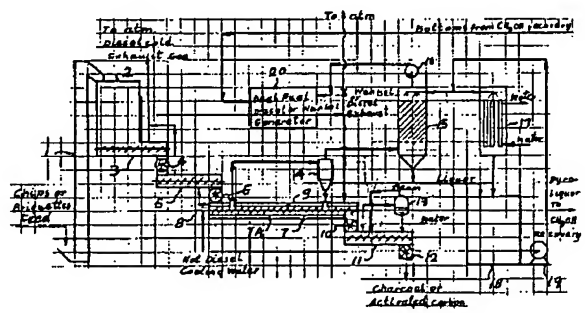
(54) PROCEDE DE PYROLYSE EN CONTINU DE COPEAUX DE BOIS ET D'AUTRES MATIERES CELLULOSIQUES VISANT A MAXIMISER LE RENDEMENT EN METHANOL, EN D'AUTRES PRODUITS ORGANIQUES LIQUIDES ET EN CHARBON ACTIF

(54) PROCESS FOR CONTINUOUS PYROLYSIS OF WOOD CHIPS AND OTHER CELLULOSIC MATERIALS WITH THE OBJECTIVE OF MAXIMIZING THE YIELD OF METHANOL, OTHER LIQUID ORGANICS, AND ACTIVATED CARBON

(57)
This invention relates to a new continuous method of pyrolysis of wood chips or compacted cellulosic materials in the absence of oxygen. Positive displacement of chips, by means of a screw conveyor, brings them into contact, in a countercurrent manner, with the newly formed reactants, which are cooled instantaneously, as they are withdrawn from the reactor. Heating of the charge is thus partially affected. The fast removal of methanol from the pyrolysis zone and its subsequent cooling by the chips prevents its decomposition .Final heating of the charge is done by means of hot internal combustion engine exhaust gases, which are passed through the jacket surrounding the screw conveyor. The partially cooled exhaust gases are,then contacted with the chips in the preheater in a countercurrent manner, before being exhausted into the atmosphere.



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(54) Titre : PROCEDE DE PYROLYSE EN CONTINU DE COPEAUX DE BOIS ET D'AUTRES MATIERES CELLULOSIQUES VISANT A MAXIMISER LE RENDEMENT EN METHANOL, EN D'AUTRES PRODUITS ORGANIQUES LIQUIDES ET EN CHARBON ACTIF

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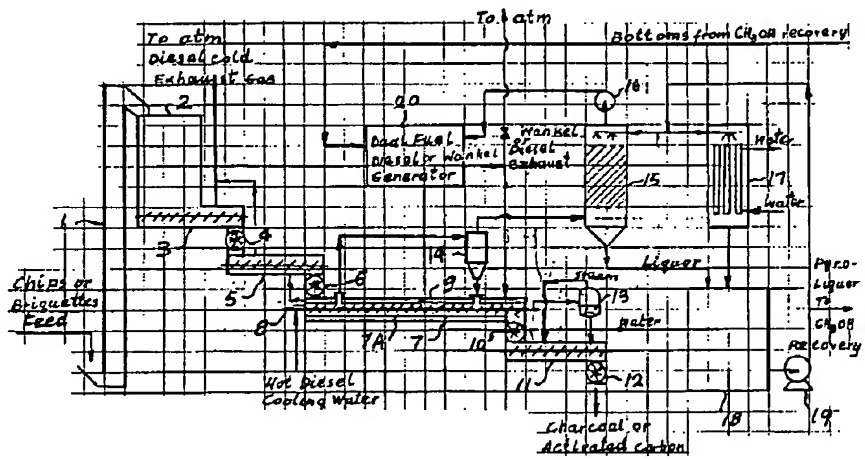

(57) Abrégé/Abstract:

This invention relates to a new continuous method of pyrolysis of wood chips or compacted cellulosic materials in the absence of oxygen. Positive displacement of chips, by means of a screw conveyor, brings them into contact, in a countercurrent manner, with the newly formed reactants, which are cooled instantaneously, as they are withdrawn from the reactor. Heating of the charge is thus partially affected. The fast removal of methanol from the pyrolysis zone and its subsequent cooling by the chips prevents its decomposition. Final heating of the charge is done by means of hot internal combustion engine exhaust gases, which are passed through the jacket surrounding the screw conveyor. The partially cooled exhaust gases are,then contacted with the chips in the preheater in a countercurrent manner, before being exhausted into the atmosphere.

Process for Continuous Pyrolysis of Wood and other Cellulosic Materials with the Objective of Maximizing the Yield of Methanol, other Liquid Organics, and Activated Carbon.

This invention relates to a new continuous method of pyrolysis of wood chips or compacted cellulosic materials in the absence of oxygen. Positive displacement of chips, by means of a screw conveyor, brings them into contact, in a countercurrent manner, with the newly formed reactants, which are cooled instantaneously, as they are withdrawn from the reactor. Heating of the charge is thus partially affected. The fast removal of methanol from the pyrolysis zone and its subsequent cooling by the chips prevents its decomposition .Final heating of the charge is done by means of hot internal combustion engine exhaust gases, which are passed through the jacket surrounding the screw conveyor. The partially cooled exhaust gases are then contacted with the chips in the preheater in a countercurrent manner, before being exhausted into the atmosphere.

Background of the Invention

Methanol or wood alcohol, as it used to be called in the past, was produced by means of heating hardwood blocks in an autoclave in the absence of oxygen. It took about four hours to pyrolyse the charge, followed by cooling of the charge in the closed autoclave. This being a batch process, with very low heat transfer rates, is no longer economical. New processes have been developed, for the production of methanol, utilising petroleum products for its synthesis, such as methane, propane etc. The simplest synthesis to mention, is from carbon dioxide and hydrogen, which can be obtained from coal or by electrolysis of water. Such processes require very high pressures and recirculation of the reacted components. Therfore, considerable investment is required to put up such manufacturing plants, and they have to be located close to the well heads. Thus, methanol can be produced at relatively low cost, but the cost of distribution can be considerable, if the location of the plant is far away from the region where it is required. However, in the not to distant future, one can foresee a depletion of petroleum reserves, and mankind should be looking for renewable sources of energy and chemicals. Sun is the only source of inexhaustible energy for thousands of years to come. Trees capture Sun's energy in the most efficient manner as they convert water, carbon dioxide etc. into wood, which can be harvested in an economical way. Of course, other plants can contribute many valuable products for various purposes, and can be a source of cellulose as well.

Over the years attempts have been made to convert wood and other cellulosic materials into diesel-like fuels. In the late sixtieth for example "de Lacote" modified his "gazogene" to produce such fuel in fixed bed reactor from 20-25 cm long logs. Duvant corporation built such plant and operated a 2 000 kW Dual-Fuel diesel generators, utilising this fuel. But, the overall energy efficiency was in the order of 25%. Another attempt to convert cellulosic matter into organic liquids and gases was made by Bernard L. Schulman, US Pat. No. 4210491, whereby the inventor proposed to use a retort in the form of a screw conveyor inserted in a vessel and heated by means of a fluidised bed around it, formed from solid products of the pyrolysis, which are

introduced into the fluidised bed compartment. In this process the products of pyrolysis are withdrawn from the reaction zone at the end of the reactor, or at several points, in a concurrent manner, then cooled outside the reactor by externally located heat exchanger. In my system the products of pyrolysis are cooled by the incoming chips (charge), since they are withdrawn from the reactor in counter-current manner, so that they give up their heat to the incoming chips, and thus decomposition of vapours such as methanol is prevented by excessive temperature. ,More recent efforts to convert biomas into fuel have taken the approach of grinding wood into powder, before subjecting it to high temperature pyrolysis. In this manner, pyrolysis was achieved in a very short time. For example, D.S.Scott et al (US Patent No.5 395 455, March 1995) shows reaction time of only 0.5 seconds at 450-490 degrees Centigrade, when processing hemlock sawdust. However, analysis of the liquid fuel, as given in the patent, shows only 8.8% total yield of liquid fuel, but no methanol. Also, Freel Barry A et al Cdn Pat. No.2 009 021 of Ensyn Eng. Associates Inc. have devised and built a plant, which can pyrolyse finely ground wood at 500-550 degrees Centigrade in a very short time i.e 0.6-1.3 seconds. Liquid fuel yields of 55-72.5 % were claimed, but methanol content has not been disclosed . Yet, literature on the early process for wood alcohol shows that 265 U.S.gallons of pyroligneous liquor were obtained from one cord of hardwood, of which about 80% was methanol. An economic analysis of my continuous new process for manufacture methanol from wood is economical, because the yield of methanol is as high as that of the early wood alcohol process. And a very valuable activated carbon is obtained. Yet, fast heat transfer rates and nearly 80% energy utilisation is achieved. Also, production plants can be located close to the markets, so that distribution cost can be reduced.

Pyrolysis Under Wood Internal Pressure

When a log of wood is heated to a temperature at which cellulose polymer chains break up into small reactive components, an internal pressure develops inside the tracheids. These reactive components, being at a very high pressure, regroup to form new smaller compounds, such as methanol, which is then released along the grains, out of the wood structure. Carbon monoxide and formaldehyde is also formed. The chemical reactions are graphically represented in Fig.2. If however, the newly formed methanol is subjected to a high temperature, after being released out of the wood structure, it will crack into smaller components, such as methane, hydrogen, carbon monoxide etc. This hypothesis explains why in the rapid pyrolysis of small particles of wood, the yield of methanol falls practically to zero. If the capillary tracheids are cut up, the reactive components are released out into the open, before they have a chance to form new compounds; this is because, reforming can only be done under high pressure, and in a small particle of wood, high pressure can not be developed. However, my experimental work has shown that pyrolysis of wood chips, such as being used in the pulp and paper industry, can give high yields of methanol. Up to now, however, no viable process has been developed to manufacture methanol from wood chips.

Summary of the Invention

My present invention comprises a process and apparatus which enables economical manufacture of methanol from wood chips and biomass. The old method of pyrolysing wood in the form of blocks, no longer economical, has been replaced by a continuous process, which consists of specially designed reactor in the form of a screw conveyor with a double shell. The rotation of the screw controls the retention time of chips in the pyrolysis zone. Chips extractor withdraws chips from the silo and feeds them into a preheater at a controlled rate. Chips preheater screw moves the charge into the reactor, from which the pyrolysed chips are discharged, already in the form of charcoal, into the cooler, which aslo serves as the carbon activator. Heating of the reactor is done by means of internal combustion engine exhaust gases or a suitable gas fired turbine exhaust. Exhaust from a Wankel engine can be used for this purpose. The exhaust gas enters the jacket of the reactor, where it gives up some of its heat to the charge through the inner shell of the reactor. From the reactor shell the partially cooled exhaust gas is then admitted into the chip preheater, where it is contacted with the chips counter currently to their flow, giving up most of the heat to the charge, before being discharged into the atmosphere. The volatile products of pyrolysis are withdrawn from the reactor in a counter current way to the flow of chips, are getting cooled immediately, while preheating the incoming chips. In order to prevent mixing of the volatile products of pyrolysis with the exhaust gases, each unit is separated by a rotary feed valve. The volatile products of pyrolysis, partially cooled, are passed through a cyclone to remove fines, which are returned back to the reactor, while the cyclone exhaust is cooled in a scrubber by means of precooled pyroligneous liquor, which is the condensed product of pyrolysis. Precooling of the pyroligneous liquor is done by means of a indirect heat exchanger with cold water. This heat exchanger can be of the type as used in for the paper machine, or such as specified in my Cdn. patent No.1 231 014, which is inexpensive to manufacture. The pyroligneous liquor is then sent to a distillation unit to separate methanol from the 'pyro liquor'.
It should be finely mentioned that in order to limit the temperature of the reactor screw conveyor shaft, the shaft is in the form of a tube, equipped with special rotary seals, so that coolant can be passed through, which can be water or steam, as required. The reactor conveyor can be of the 'hollow flite" type, which can provide additional heating or cooling, as required. However, a better heat economy is obtained, if the conveyor is made of high temperature resisting alloy, and steam is used as cooling medium, which then can be used to activate the charcoal, leaving the reactor.
It is evident from the foregoing description, that the new process can convert wood into methanol in a viable way, which is much more economical then converting it into electric power directly. A source of renewable energy and a valuable product of activated carbon is also provided.

Brief Description of the Drawings

Details of the embodiments of the invention are given in the accompanying drawings:
Fig.1. is a schematic flowsheet of major equipment needed to carry out the pyrolysis of wood chips or compacted biomass at a positively controlled rate and uniform temperature. A list of major equipment used is also given.

Fig.2. shows chemical reactions envolved in the decomposition of cellulose by pyrolysis, whereby methanol is formed.

Detailed Description of Preferred Embodiment

Pyrolysis of wood chips or other cellulosic materials is carried out in a reactor (7) which is essentially a pipe (7A) with an Archimedes type screw (8) inserted inside, and an external jacket (9). The Archimedes screw (8) has a hollow shaft to which flights are attached. The flights can be the hollow type, so that a cooling or heating medium can be passed through it. For example, if the flights are made of copper, to prevent decomposition of methanol, then a cooling fluid could be used to preserve its strength at higher temperatures. If however, more heat transfer area is required for higher production rates, then heat resisting steels or alloys can be used for the manufacture of flights. In the preferred mode of operation, heating of the chips is accomplished through the wall of the screw conveyor shell (7A) by Wankel engine exhaust gas, fed into the conveyor jacket space. The reactants from the pyrolysed Charge (chips) are withdrawn from the reactor counter currently to the progressive movement of chips, thus giving up its heat to the charge (chips). Preheating of chips is done in the preheater (5) by direct contact with the engine exhaust, which is withdrawn from the reactor jacket, and passed into the chip preheater, where it gives up most of its heat and gets purified, before it is discharged into the atmosphere. Chips (or briquettes) are withdrawn from the feed silo (2) by the screw extractor-feeder (3) , and then enter the preheater (5) through the rotary valve (4). Rotary feed valves (4,6,10& 12) prevent mixing of the volatile reactants with the heating media, such as engine exhaust gases, for example, or gas turbine electro-generator exhaust.
It should be noted that as the chips or briquets are moved along the reactor (7), and are progressively heated to higher temperatures, the products of pyrolysis like methanol for example, are immediately withdrawn and cooled by the incoming colder charge. This prevents exposure of methanol to high temperature and its eventual destruction. The partially cooled reactants are withdrawn from the reactor entrance, and then are passed through the cyclone (14) to drop fines back into the reactor, while the volatiles are passed on to the condenser (15), where the vapours are condensed by direct contact with the precooled pyroligneous liquor. The pyroligneous liquor is cooled in the plate type heat exchanger (17) as mentioned before. The pyroligneous liquor is collected in the tank (18), where from it is transferred to the methanol recovery plant, and separated from the pyroligneous liquor by distillation. The left over product of pyrolysis, charcoal is then discharged through the rotary valve (10) into the cooler (11) where it is treated with steam, to activate it .The thus produced activated carbon is further cooled with water, before it is discharged through the rotary valve (12) to storage and the granulating system. The noncondensable combustible gases are drawn from the condenser (15) by means of a suction fan (16) then transferred to the electric power generation plant, such as dual-fuel diesels, gas fired turbines, Wankel engines or boilers. The bottoms from the pyroligneous liquor still, (pyro liquor), can be used as fuel in power generation, or used yield other organics, such as acetic acid for example.

Claims:

1. A process for nondestructive continuous pyrolysis of wood chips, in which yield of methanol is maximised while the heavier organics in the pyroligneous liquor and the noncondensable combustibles are used in electric power generation, while the left over charcoal is converted into activated carbon.
This process comprises:
(a) Introducing wood chips into the tube type screw conveyor which has external jacket for progressive heating of the uniformly propelled charge by means of the hot volatile products of pyrolysis.
(b) Instantaneous withdrawal and cooling of the products of reaction in a countercurrent manner so as to affect their cooling and provide heat to the incoming charge.
(c) Cooling of the hollow shaft of the reactor conveyor by means of steam, which is then used to activate and cool the charcoal after its withdrawal from the reactor.
(d) Isolation of the volatile products of pyrolysis by means of rotary valves.
(e) Direct and indirect heating of wood chips in a countercurrent manner by means of exhaust gas from a Wankel engine driven generator, or by means of exhaust gases from turbine driven electric power generator, or by hot gases generated by combustion of fuel.

2. A process as claimed in claim (1) where the pyrolysed material used in the production of methanol is briquetted biomass.

3. A process as claimed in claim (1) except that the hollow flites of the pyrolytic reactor are cooled by a heat transfer medium, which is then used to heat the chips (charge).

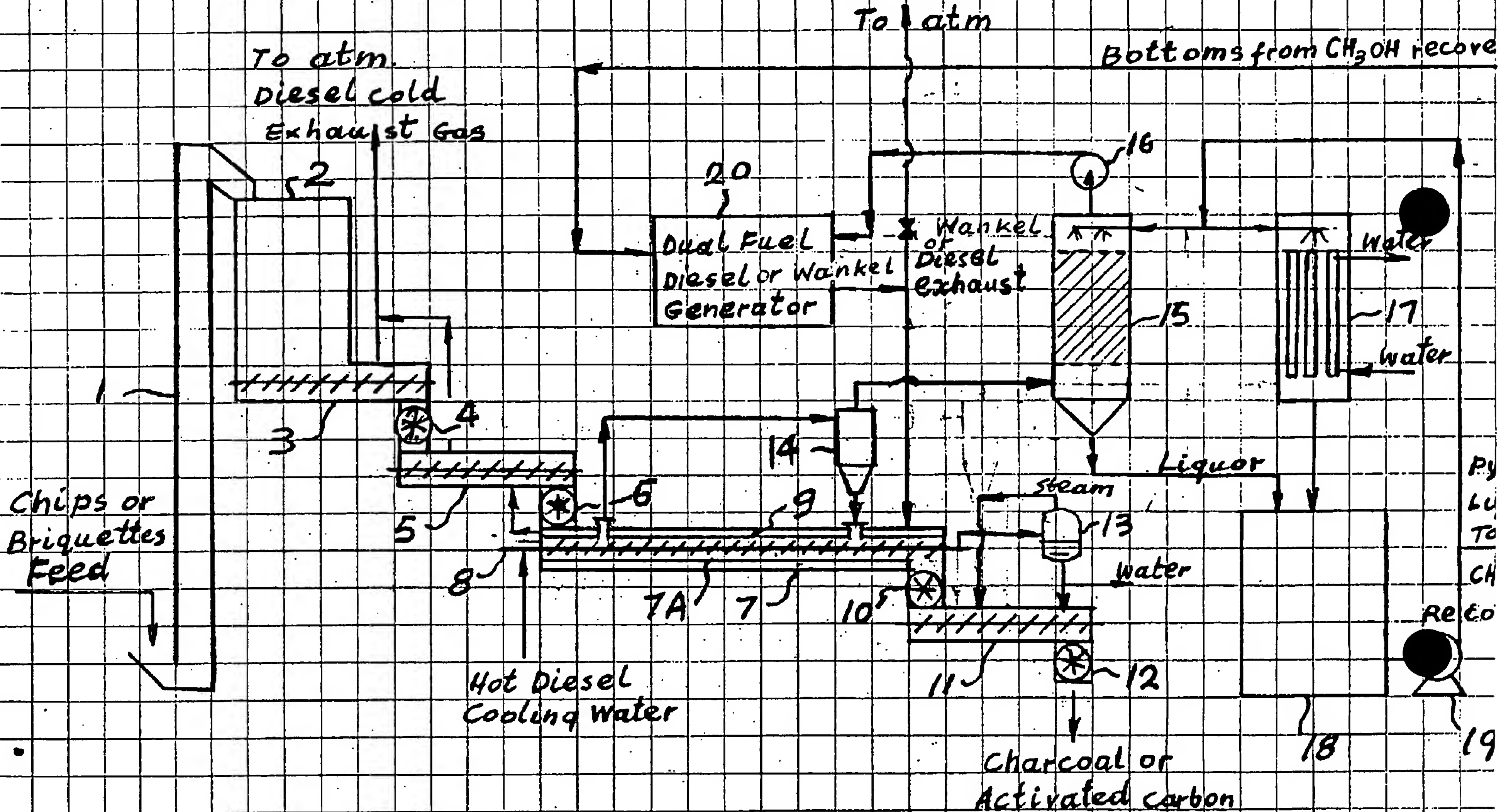
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FIG. 1

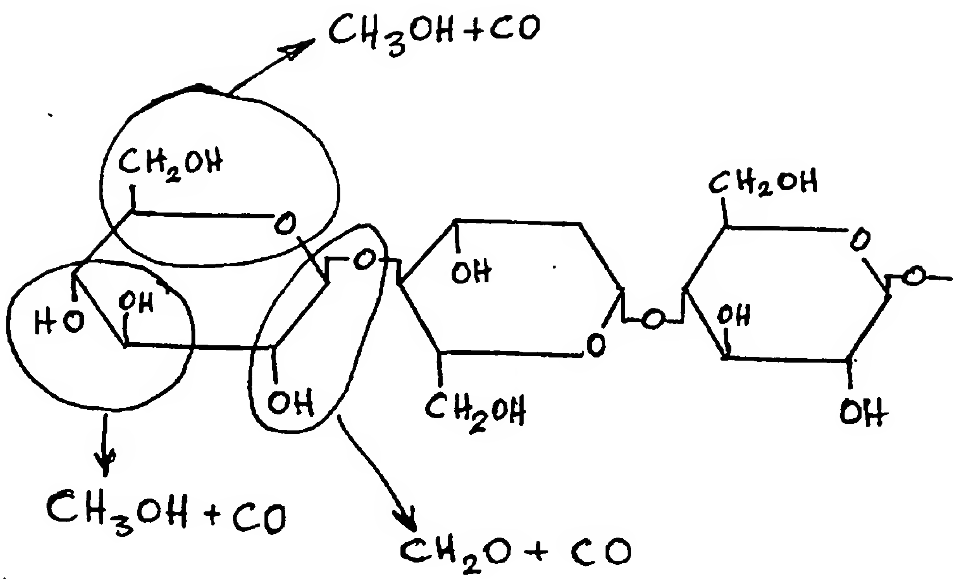

FIG. 2